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PALEOBOTANY IN THE POST-
GENOMICS ERA:
INTRODUCTION^{1, 2}

William L. Crepet³ and Maria A. Gandolfo⁴

Today, significant biological questions are being addressed in the aftermath of the genomics revolution in ways that suggest a remarkable understanding of life is now within our grasp. Post-genomics techniques are powerful, intriguing, and full of promise. In addition to the tools grouped under bioinformatics, we are now seeing the emergence of ancillary but complementary and informative technologies that are increasingly important, including breakthroughs in optical imaging such as confocal microscopy and various microarray methodologies. Such new techniques are helping us understand the cascade of information provided by genomics and are already yielding important insights into plant biology. These include advances in understanding cell structure and function, control of gene expression, and intercellular communication that will inform our understanding of plant development and thus, ultimately, homologies. Genomics data are also vital to understanding the relationship between the organism and environment, and a better understanding of this relationship combined with better understanding of homologies will provide new insights into plant evolution, especially in the context of another

post-genomics-era advance—comparative studies that allow estimations of phylogenetic relationships among extant taxa based on DNA sequence data using various algorithms. Phylogenetic context is a powerful tool for understanding many aspects of the history of life including those involving paleoecology and past distributions. Phylogenies based on gene sequence data are also increasingly being used to date key evolutionary events through various molecular clock-based models. Dating key events in the past is critical to understanding the diversity and nature of life today. Thus, in the post-genomics era, many tools of molecular biology have implications for understanding aspects of plant life that were once illuminated exclusively by fossil evidence or inferred from comparative studies of extant taxa based on morphology and anatomy.

Now, in the excitement associated with the proliferation of genomics data, there is such reliance on various molecular genetic-based approaches and so much hope assigned to future applications of such methodologies that fossil data are in some danger of either being ignored or, because many fossil identi-

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³ Department of Plant Biology, Cornell University, Ithaca, New York 14853, U.S.A. Author for correspondence: wlc1@cornell.edu.

⁴ L. H. Bailey Hortorium, Department of Plant Biology, Cornell University, Ithaca, New York 14853, U.S.A.
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fications in the literature have been inadequately justified, misapplied when they are used at the critical interface between genomics and paleontology. Thus, there is the possibility that the full value of fossil data in the context of genomics and post-genomics studies may not be fully realized at the very moment when these data might have the most significance.

This symposium issue is dedicated to emphasizing the value of the fossil record by discussing issues likely to be important in the post-genomics era. There are too many areas where fossils have importance to include here, but certain issues and subjects are covered in some depth. In the first paper, Crepet further considers the value of the fossil record in general and specifically with respect to understanding angiosperm history. Gandolfo et al. discuss the importance of fossil selection in calibrating analyses using various timing models. Nixon considers the conflict between timing suggested by the fossil record versus timing inferred from the application of molecular clock-based dating using a specific example. Such conflicts are often attributed to flaws (i.e., incompleteness) in the fossil record. Burnham considers the accuracy of the fossil record directly and addresses some widely held notions about lag time while pointing out imperfections based not on the record itself, but on the level at which it has been studied.

Integration of fossil and modern data is an important recurring element in the post-genomics era, and in this symposium this issue is approached in a variety of ways. Hermsen and Hendricks consider difficulties and benefits associated with integrating molecular sequence data from modern taxa with morphological/structural data from fossil and extant organisms in phylogenetic analyses aimed at elucidating character evolution. Endress reveals a creative and very interesting application of comparative floral organogenesis in extant taxa that has the potential to amplify the information retrievable from the fossil record, while Rothwell et al. illustrate interesting

potential in the interface between the fossil record and molecular biology. They provide fossil evidence relevant to the regulation of cambial activity by auxin through time and in various clades. In so doing, they add yet another dimension to paleobotanical studies.

Biogeography and paleoecology are areas of particular and traditional importance in paleontology and ones critical to understanding the evolution of life. There is no neontological substitute for the information made available through such investigations, but modern data and analytical techniques are vital to informing these studies. Tiffney takes on biogeography in the context of post-genomics-era methodologies using phylogenetics, applications of “physiological uniformitarianism,” and key fossil data in concert to evaluate certain phylogeographic hypotheses and to identify new ones. DiMichele and Gastaldo provide a comprehensive treatment of the interface between neoecological techniques and paleoecology. They illustrate how reciprocity between advances in paleobotany/paleoecological methods and modern ecological theory/methods holds great potential for a better understanding of the changes in Hutchinson’s “ecological theater” through time and thus promises to impact our understanding of his “evolutionary play.”

There are several themes emerging from this collection of papers. It is clear that new methodologies are critical to increasing the value of fossil evidence and, reciprocally, that fossil evidence is important in exploiting many of these advances. Furthermore, it is likely that fossil data will be increasingly important as new informative techniques emerge that we cannot now imagine, just as we could not predict the value of fossils in the context of today’s techniques 30 years ago. It is also very clear that the value of the fossil record, now so informative in so many areas, is limited by the accuracy of fossil descriptions, stratigraphic settings, and identifications. In the end, it is one of the most basic aspects of paleobotany that counts the most.